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AUTHORITY

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Interim Report No. 2

of the

VARIABLE-SPEED RECORDER-REPRODUCER

Second Quarterly Progress Report, 6 November 1962 to 12 March 1963

to

U.S. Army Signal Research and Development Laboratory
U.S. Army Signal Supply Agency
Fort Monmouth Procurement Office
Fort Monmouth, New Jersey

In response to Contract No. DA 36-039 SC-89067

ASC 403

12 March 1963

Best
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Interim Report No. 2

on the

VARIABLE-SPEED RECORDER-REPRODUCER

U.S. Army Signal Supply Agency
Fort Monmouth Procurement Office

In response to Contract No. DA 36-039 SC-89067

Second Quarterly Progress Report, 6 November 1962 to 12 March 1963

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The object of this project is to design and construct an engineering test model of a rack mounted, audio recorder-reproducer using a plastic base oxide coated tape and capable of operation at selectable variable tape speeds.

Prepared by

John L. Toth
Donald E. Reed

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LIST OF ILLUSTRATIONS

PURPOSE

The purpose of this contract is to design and construct an engineering test model of a rack mounted, audio recorder-reproducer using plastic base oxide coated tape and capable of operation at variable tape speeds. The recorder-reproducer should accept two signals for simultaneous dual track recording and playback.

The above work was proposed to be carried out in six phases.

The first and second phases were completed during the early part of the contract and are covered in Interim Report No. 1. The third phase, which includes "Prototype Test and Final Design" was also started during this time and completed during the second period. This area is covered in the present report. Phase No. 4 "Procurement and Manufacture of Three Units" was under way at the latter part of the period covered by this report, and is still going on.

ABSTRACT

This report covers:

1. Finalization of the prototype circuit design and tests carried out on same. During this period we encountered the problem of hum-elimination in the high-gain playback amplifier. Equalization circuits were finalized. In the tape transport mechanism we had several mechanical problems. Certain design changes were necessary to bring the wow and flutter below the level required by the specifications.

2. Finalization of the mechanical design and packaging of both the electronic unit and the tape-deck unit. Printed circuitry was chosen for the electronic unit and conventional wiring for the tape deck itself.

A mechanical model was built, the printed boards designed and made. At the end of the period covered by this report the model was ready for assembly.

FACTUAL DATA

Completing the circuit design in the electronic unit, the following was done:

<u>Playback Amplifier</u>

A few modifications were carried out in the playback amplifier. The circuit was quite sensitive to hum pick-up, which was traced to several sources. A higher voltage DC source (25v) for the filament supply was installed which allowed better filtering and lower ripple, hence less hum introduced by the filaments. The major source of hum was found to be the cathode follower input tube, with the associated components and cables. This stage has been completely eliminated and the playback head is now connected through shielded cable direct to the grid of the first amplifier tube. This greatly reduced the hum. Improved decoupling in the B+ supply line also contributed to hum reduction.

Another problem was that the 60 Kc bias frequency registers on the tape, and in playback this signal came through since the amplifier response is still quite good at this frequency.

Raising the bias frequency to 100 Kc placing a tuned trap in the plate circuit of V-101 (first half) and an LC low-pass filter in the grid of V-102 (first half) cuts this disturbing signal to a barely detectable level.

The higher bias oscillator frequency has another advantage. In use there will be cases when recordings are made at 20 ips and played back at 1 ips. The frequency of the recorded signal will this way be reduced by a ratio of 20:1, but so will the bias frequency which also registers on the tape. (In our example a 60 Kc bias signal became a 3Kc audible tone.) This signal can be disturbing. Fortunately the combined response of the record head and the tape is so much poorer at 100 Kc, that this disturbance becomes very small. Another helping factor here is, that -- taking our example -- with the playback equalizer set at 1 ips, the combined response of the playback head and the amplifier produces a lower output signal at 5 Kc than at 3 Kc.

An amplifier stage was added to the playback amplifier with a 600 Ohm output transformer to produce the low level playback output required by the specifications. This same tube delivers power to drive a monitor headset.

A monitor switching circuit has been added to the design, and has a dual function. One pole connects the indicating meter into various circuits of the equipment, thereby providing level indication for recording, playback, erase and bias. Another pole connects the jack for the monitoring headset either into the playback or the recording channel.

Recording Amplifier

In the recording amplifier an amplifier stage was added to drive the monitoring headset.

The only other major modification was the change of Vari-L Model PA-36 to Model TF-2X10. This was done in order to combine the mechanical speed control knob with the recording equalizer.

The mechanical integrator has a control ratio of 1:6, which produces a linear change in speed with a 1:6 ratio on each range. (LOW=1 to 6 ips; HI=5 -30 ips.) The first selected Vari-L (PA-36) was not able to produce this range linearly and had to be changed to TF-2X10 which has a much wider linear range. See Fig. 1.

Erase - Bias Oscillator

The only modification made here was the increase in frequency. 100 Kc appears to be the upper limit for the ferrite-core transformer, which at this frequency is still capable of supplying sufficient erase power for these particular Brush heads.

Electronic Tape Transport Control

The circuitry in the Transport Control was changed somewhat with respect to Fig. 37 in Interim Report No. 1. Another position was added to the four-position switch to accommodate an additional

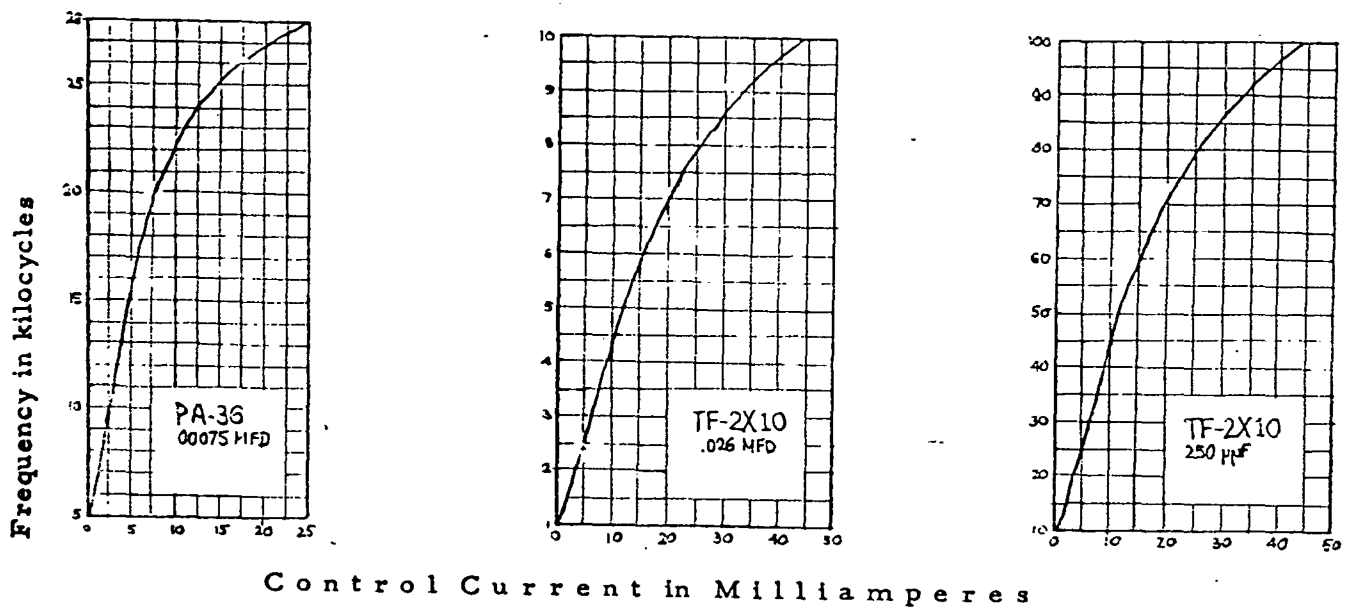


FIGURE 1.

Comparison between VARI-L,s Mod. PA-36 and TF-2X10. Mod. ГF-2X10 is shown with two different values of capacitors.

STOP position.

During our tests we did not find any occurrence of tape breakage, nor any such tendency, therefore the tape break relay (RY3) was omitted with its associated circuitry.

RY-1 was modified into a PAUSE relay, and a PAUSE push-button switch was added. This permits stopping and starting the tape in the Record mode simply and easily.

The pressure roller first was actuated by a 110 v a-c solenoid, but too much noise (audible) was generated. Replacement with a d-c model results in quieter operation. A separate solenoid was added to operate the fork that keeps the tape away from the heads in REWIND and FAST FORWARD.

Power Supply

The hum was further reduced by adding additional decoupling RC networks in the B+ supply.

Another modification in the Power Supply was the change from a 6 vdc filament supply to a 25.2 vdc supply. This further aided hum reduction.

The Circuit Diagrams of both the electronic and tape deck units can be found at the end of this report.

Tape Transport Mechanism

Tests first carried out on the transport mechanism described in Interim Report No. 1 (pages 83 to 85) indicated that at certain speeds wow and flutter was above the level specified in the specifications.

It took some time before the causes were found and corrected.

One contributing factor was found to be the tape guide pins. In order to keep costs down, instead of using expensive ball-bearing rollers guide pins were selected. As the tape moves past these guide pins a certain amount of friction is generated. This friction force unfortunately varies with the pulling force. The pulling force on the other hand is subjected to various factors, for example the distribution of tape between the supply and takeup reels, reel eccentricity or warpage, density of tape wind (loose or tight), splices, mechanical vibration, and similar. To reduce the effect of these on the tape at the heads, a flywheel with a moment of inertia equal to 0.7 lb in^2 was added to the capstan shaft. This resulted in some improvement at high speeds and more stable operation. Then another flywheel was used with 4.0 lb in^2, but offered no significant improvement over the first one. Since the application of a small flywheel appeared to be advantageous, it was decided to incorporate one with approximately 1.0 lb in^2 inertia into the system. It is connected to the output (capstan) shaft of the integrator.

The amount of tape (both by its weight and diameter) affects wow and flutter. The more tape, the higher the inertia, the smoother the tape pull. This point was improved by adding weight to the reel hub in form of a plate on which the plastic tape reels rest. This has an added advantage. Since its diameter is larger than that of a small 5-inch plastic reel, an eventual loose loop cannot possibly get under it and tangle up.

A further step taken towards reduction of wow and flutter was decreasing the wrap angle at both the heads and the guide pins. Both of these result in more uniform tension and smoother operation.

During the tests a slow transverse motion of the tape was noticeable as it ran past the heads. This was eliminated by placing a plastic guide block between the record and playback heads.

With all these design changes the wow and flutter was cut down to .15 to .45% depending on tape speed.

The originally selected sprag-clutches were changed for a make that costs less and offers slightly less friction in the forward direction.

In the initial design the sprag-clutch housing was a separate unit. In the improved design this was combined with the torque motor support. This has the advantage of reducing the number of parts and eliminates a formerly difficult alignment problem.

An improvement was made in the solenoid actuation circuit.

In the original design one solenoid actuated the tape pressure roller, which through mechanical linkage moved the tape lift-off fork. The new design employs one separate solenoid for the pressure roller and another one for the lift-off fork. In this way the pressure roller is away from the capstan except during recording and playback and no permanent deformation of the rubber roller can result from the (previously) constant pressure on it.

FINAL LAY-OUT AND PACKAGING

Electronic Unit

In the lay-out and packaging accessibility, ease of servicing and compactness were kept in mind in addition to the electrical requirements and ease of operation.

A major aspect of the mechanical construction is that the unit will be subjected to severe vibration and shock tests.

Since the recorder has two identical channels of operation, it was decided that one record and one playback amplifier will be combined into a single compact plug-in unit. The complete unit uses two of these plug-in units and they are completely interchangeable. This idea has several advantages: Manufacturing is simpler; In case of breakdown in operation, the inactive channel can be unplugged and serviced while the other one carries on, or a spare unit can be plugged in for that time; Servicing of this plug-in unit is easier. Printed board design was used within the plug-in units, one for each amplifier. When spare boards are available, servicing a unit amounts to changing the board only.

The electronic chassis can be roughly divided into three sections. The middle third is occupied by the power supply in an enclosed area. The loudspeaker is mounted on the front panel in this area. The plug-in units slide into the unit on either side of the power supply and they are interchangeable.

The power amplifier mounts on the side wall of the power supply at the rear end of the chassis. The contract calls for one power amplifier, but space has been left so that it can be duplicated for a second channel on the opposite side wall if need calls for it.

One mechanical model was designed and built following these principles and has worked out very well. The printed boards have all been designed and made. At the time this report is written, the unit is ready for assembly. Fig. 2 is a photograph of this model.

Tape Deck

The basic layout of the initial design was not changed substantially. Most of the components of the Electronic Tape Transport Control were packaged into a complete unit in a housing and mounted on the side wall of the U-shaped frame work.

All motors and the mechanical and electromechanical components are easily accessible for repair or servicing.

The heads are mounted on a small adapter plate which is bolted to the front panel of the tape deck. Behind the front panel and just below the adapter plate, the bias oscillator is located in a shielded box.

An artist's concept (mounted on a standard rack MIL STD 189) of the complete recorder-reproducer is shown on Fig. 3.

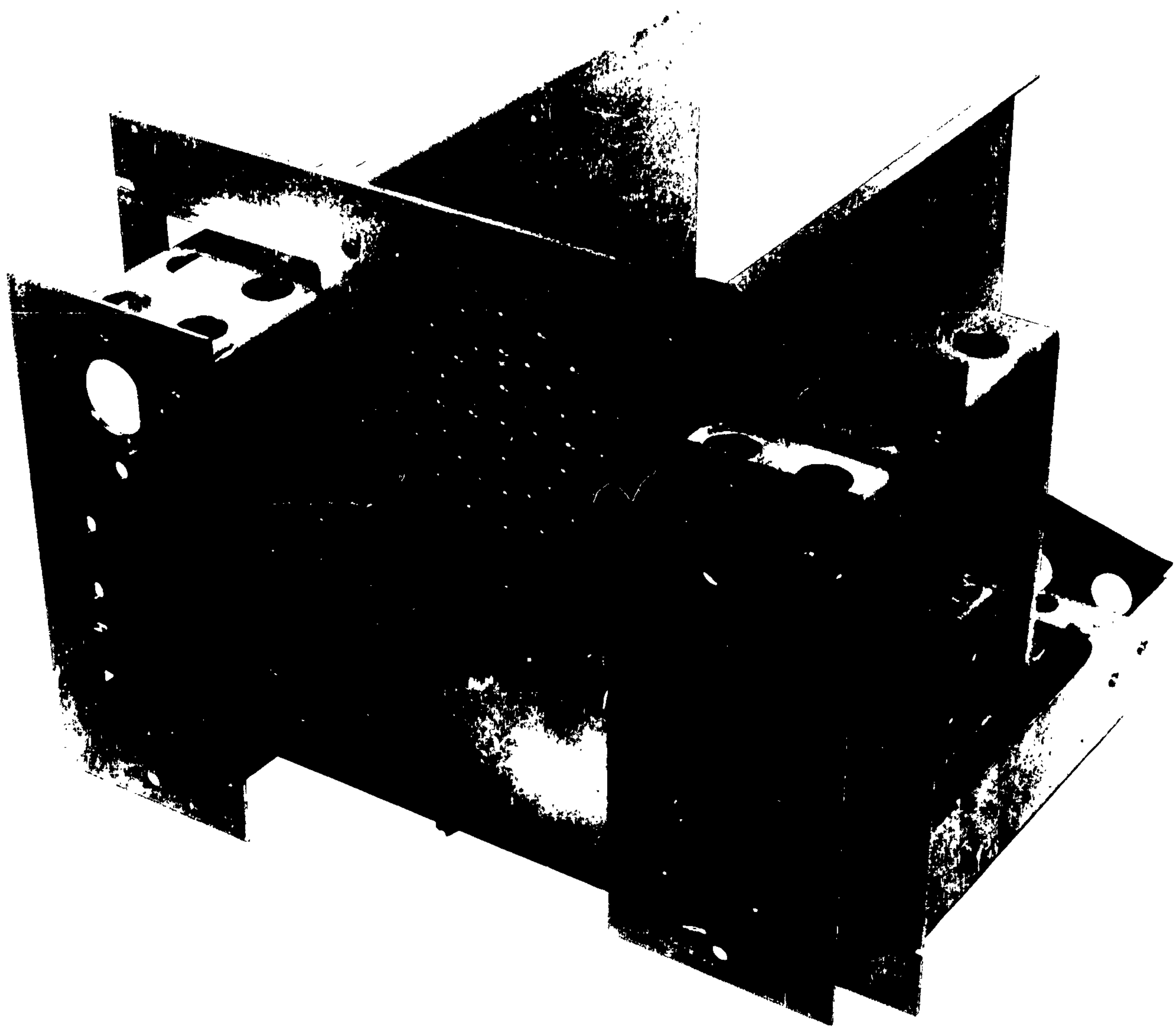


FIGURE 2.

Electronic Unit
Mechanical Design

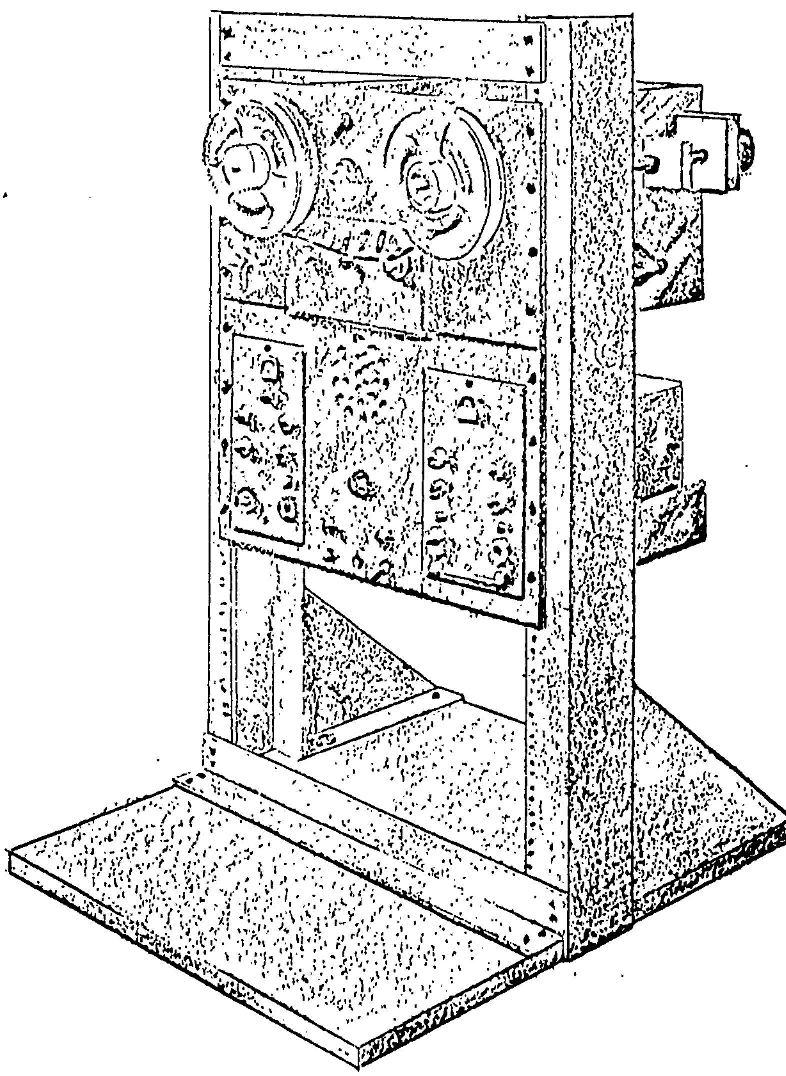


FIGURE 3.

CONCLUSION

The design can be considered to be finished. Minor "bugs" can be expected in the first production unit built, but no real difficulties are expected.

The elimination of wow and flutter presented difficulties and required considerable effort.

In the electronic unit elimination of hum was the major problem.

Efforts during the period resulted in lowering these disturbing signals below the level required by the specifications.

Lay-out and packaging was completed during the period, and final assembly started.

PROGRAM FOR THE NEXT INTERVAL

We expect to complete the manufacture and testing of the three units during the next interval and deliver them along with the instruction books, etc.

IDENTIFICATION OF PERSONNEL

The following technical persons are assigned to the contract and took part in the work covered by this report:

George E. Franco, Chief Engineer and Project Engineer. Supervisory activities.

Donald E. Reed, B. S. in E. E., Senior Electrical Engineer, Project Engineer. Work performed 84 hours.

John L. Toth, B. S., Electrical Engineer. Work performed 284 hours.

Kenneth Smith, Engineer. Work performed 352 hours.

John L. Baldwin, M. S. M. E., Senior Mechanical Engineer. Work performed 263 hours.

Ralph S. Walker, Designer. Work performed 424 hours.

A brief description of the background of each of the above listed persons can be found in the following pages:

GEORGE A. FRANCO

Vice President, Engineering — TOP SECRET Clearance

Mr. Franco has had progressively important duties in the fields of communication theory and practice, and engineering administration. His record shows both basic contributions to the state of the art and skill in the difficult act of managing scientists and engineers.

EDUCATION:

Lehigh University, Bethlehem, Pa., BSEE
University of Rochester, and Massachusetts Institute of Technology
Graduate courses in Information Theory, Communication Theory, Numerical Analysis and Analog Computers.

EXPERIENCE:

American Scientific Corporation, Vice President-Engineering, 1962 to Present.

Sanders Association Inc., Communications Center, Washington, D.C., 1962. General Manager. Responsible for all technical and administrative guidance of Communications systems and techniques.

General Dynamics/Electronics, Rochester, New York,
Associate Director of Research, 1961 to 1962. Responsible for the technical and administrative direction of three research laboratories. The technical areas covered by these laboratories were Communication Techniques, Media Studies, Computation and Control, Instrumentation and Measurement, Networks, Circuits and Devices, Communication Mathematics, Systems Research.

Manager, Radio Communication Laboratory, 1958 to 1961. Responsible for the technical and administrative direction of the laboratory. The technical areas covered by this laboratory included Communication Techniques, Propagation and Coding, Microwave Techniques, Solid-state Circuits and Bio-physical Communication.

Head of the Communication Techniques Section within the Radio Communication Laboratory, 1956 to 1958. Responsible for all work in the section under the general direction of the Manager.

Development Engineer, General Electric Co., Syracuse, N. Y., 1955 to 1956. Engaged in the development of advanced electronic circuits for the Sage and ICBM program.

GEORGE A. FRANCO (Cont'd)

MAJOR DEVELOPMENTS:

Conceived and responsible for subsequent development of an Orthogonal Communication System.
Conceived and responsible for subsequent development of a Matched Filter Communication System.
Frequency Shift Keyed Receiver
Signal Detectors
Polarization Modulation Data Transmission System.

AWARDS:

General Dynamics/Elecronics Annual Award for Outstanding Achievement in Science and Technology, 1960

PATENTS:

Frequency Shift Keyed Receiver, Patent No. 2,897,269, dated 7/28/59 (6 claims).
Detectors, Patent No. 2,937,237, dated 5/17/60 (4 claims).
Polarization Modulation Data Transmission System, Patent No. 2,992,427, dated 7/11/61 (14 claims).
Also, 12 other patents applied for:
Signal Coding - 6
Modulation and Detection - 3
Speech Bandwidth Reduction - 2
Stable Signal Generation - 1

PUBLICATIONS:

"A Compatible Synchronous Radio Teletypwriter System", Proceedings of the Military Electronics Conference, Washington, D.C., July 1959

"An Orthogonal Technique for Communication", IRE Convention Record, Communication Systems, Part 8, March 1961

TECHNICAL SOCIETIES:

Research Society of America
Eta Kappa Nu. (Honorary Electrical Engineering Society)
Institute of Radio Engineers
American Institute of Electrical Engineers
American Physical Society
IRE Professional Groups on Information Theory, Communication Systems, Bio-Medical Electronics

DONALD E. REED

Senior Electrical Engineer — SECRET Clearance

Mr. Reed has 12 years of experience in electrical engineering and related fields, including electronics, instrumentation, optics, photography, photometry, and illumination. He has an exceptionally good background in control systems, servos, high speed optical scanners, and printed circuit boards and components.

EDUCATION:

Union College, 1950, B.S. in E. E.

EXPERIENCE:

National Bureau of Standards, Electrical Engineer
Reed Research Inc.

DESIGNED AND DEVELOPED:

Servo Control System for Constant Energy Spectrosensitometer
Servo Control System for Pressure Simulator
Light Source for Rectifying Projector
Special Stereo Camera
Electronic Control System for Orthographic Photogrammetric Printer
Optical and Lighting System for 70 mm Stereo-viewer
Special Scanning Camera
High Speed Optical Scanning Device for Reduction of Graphic Data
Electronic Control System for High Speed Wire Cloth Loom
Miniature High G Latching Relay

INVESTIGATED:

Advanced Techniques for Printed Circuit Board and Components
High Speed Mail Handling Techniques and Equipment
Lamp and Lens Design of Visibility Measuring Devices
Spectral Properties of Photosensitive Materials and Light Sources
Atmospheric Optics
Airport and Aircraft Lighting and Landing Devices
Magnetic Materials Applications in Microminiature Devices

TECHNICAL SOCIETIES:

Institute of Radio Engineers
Society of Photographic Scientists and Engineers
Society of Motion Picture and Television Engineers

JOHN TOTH

Senior Electronics Engineer — SECRET Clearance

Mr. Toth, a native of Hungary, has an extensive background of education and experience both in Europe and in the United States. He has designed numerous items of electronic test equipment, photoelectric instruments, and communications equipment.

EDUCATION:

Technical University of Budapest (Hungary), 1951, Diplom Engenieur (Equivalent to U.S. degree of B.S. in E.E.)

EXPERIENCE:

E.M.G. (Electronic Measuring Gear), Budapest, Hungary
  Laboratory Engineer
Hiradastechnika, KTSZ, Budapest, Hungary
  Chief Engineer, Prototype Laboratory
Reed Research Inc.
  Electronics Engineer
Nems-Clarke, Inc.
  Electronics Engineer
Space Components Inc.

DESIGNED AND DEVELOPED:

Heterodyne frequency meter
Direct reading frequency meter
Electric photoflash
LVDT displacement indicators
Distance translators
Distance integrators
VHF transmitter
Voice frequency control circuits

INVESTIGATED:

Magnetically activated environmental switch (FluxLink)
Magnetically activated environmental relay

JOHN L. BALDWIN

Senior Mechanical Engineer **SECRET Clearance**

Mr. Baldwin has broad experience, both theoretical and practical, in mechanical engineering, with special emphasis on machine design and mechanisms. He also has experience in hydrodynamics, field and laboratory testing of many types of equipment, and structural design. Mr. Baldwin is a registered professional engineer.

EDUCATION:

University of Maryland, 1952, B.S.M.E.
University of Maryland, 1956, M.S.M.E.
Additional Graduate Courses in Aeronautical Engineering and Mathematics

EXPERIENCE:

National Bureau of Standards, Student Aide
David Taylor Model Basin, Junior Engineer
Naval Ordnance Laboratory, Project Engineer
Reed Research Inc.

DESIGNED AND DEVELOPED, In Whole or in Part:

- Inertia Timer
- Various Parachute Containers
- Aerodynamic Stabilizing Fins
- Subsonic Wind Tunnel Models
- High Frequency Accelerometers
- Discriminating Accelerometers (low frequency)
- Ball Lock Release Devices
- Air Gun Diaphrams
- Explosive Drivers
- Manual Tracking Mount
- Underwater Parachute Test System
- Level Track Rocket Sleds
- Free Flight Rocket Sleds (Motors burn out before launch)
- Explosive Bolts
- Gun Mount for Model Launcher
- Lighting and Camera Housings and Supports for Underwater Photography
- Transonic Free Fall Test System

John L. Baldwin

DESIGNED AND DEVELOPED (con't.)

Supersonic Free Fall Rocket Boost Test System
Components of Several Aircraft Delivered Weapons
Metal Shipping Containers
Structures for Test Sets
Missile Handling Equipment

INVESTIGATED:

Aerodynamic and Hydrodynamic Trajectories
Aerodynamic Properties of Various Shapes
Prestressed Beam Columns

INVENTED:

Shape and Construction of an Aerodynamic Fin
Various Mechanisms Used in an Aerial Delivery System

AUTHORED:

Report on the Effect of Various Design Parameters High Drag Trajectories
Report on Water Impact Forces and Underwater Trajectories of Various Shapes
Reports of Various Field and Laboratory Tests
Reports of Various Wind Tunnel Tests

TECHNICAL SOCIETIES:

American Society of Mechanical Engineers
Tau Beta Pi

RALPH E. WALKER

Designer | SECRET Clearance

Mr. Walker has more than 14 years of experience in such fields as hydrography, mechanisms, ordnance, topography, and packaging. He has designed and developed reusable ordnance shipping containers, and also has designed missile handling equipment and stowage systems, as well as containers for various commercial items.

EDUCATION:

Graduate, Class A and B Drafting School, U.S. Navy
George Washington University (attending Engineering School)

EXPERIENCE:

U. S. Navy, Draftsman
U. S. Navy, Ordnance Designer
Reed Research Inc.

DESIGNED AND DEVELOPED:

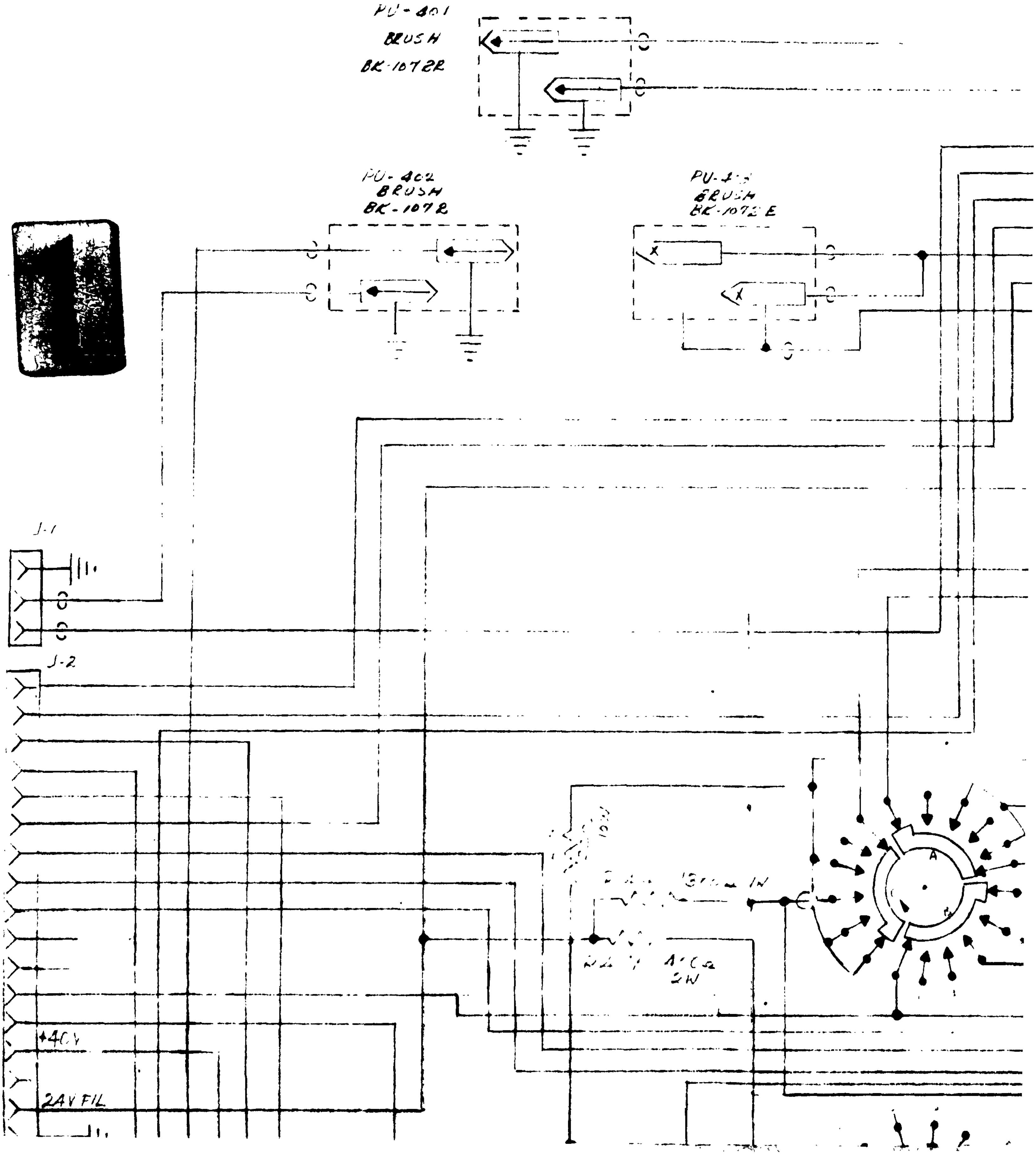
Terrier Dolly
Stacking Cradle for Talos Missile
Handling Band for Talos Missile
Talos Handling Dolly Components
Loading Rabbit for SS 580 Class Submarine
Missile Handling Equipment for NAMC
Cartridge Cases
16" Exp. Nuclear Projectile
Lightweight Jacks

INVESTIGATED:

Fixed Ammunition
Spiral Wrap Cartridge Case
30-mm. Exp. Projectile
Towing Dolly for Terrier Missile
Existing Documentation on All Naval Missile Systems pertaining to preservation, packaging, packing, handling and shipping

INSTRUCTED:

Drafting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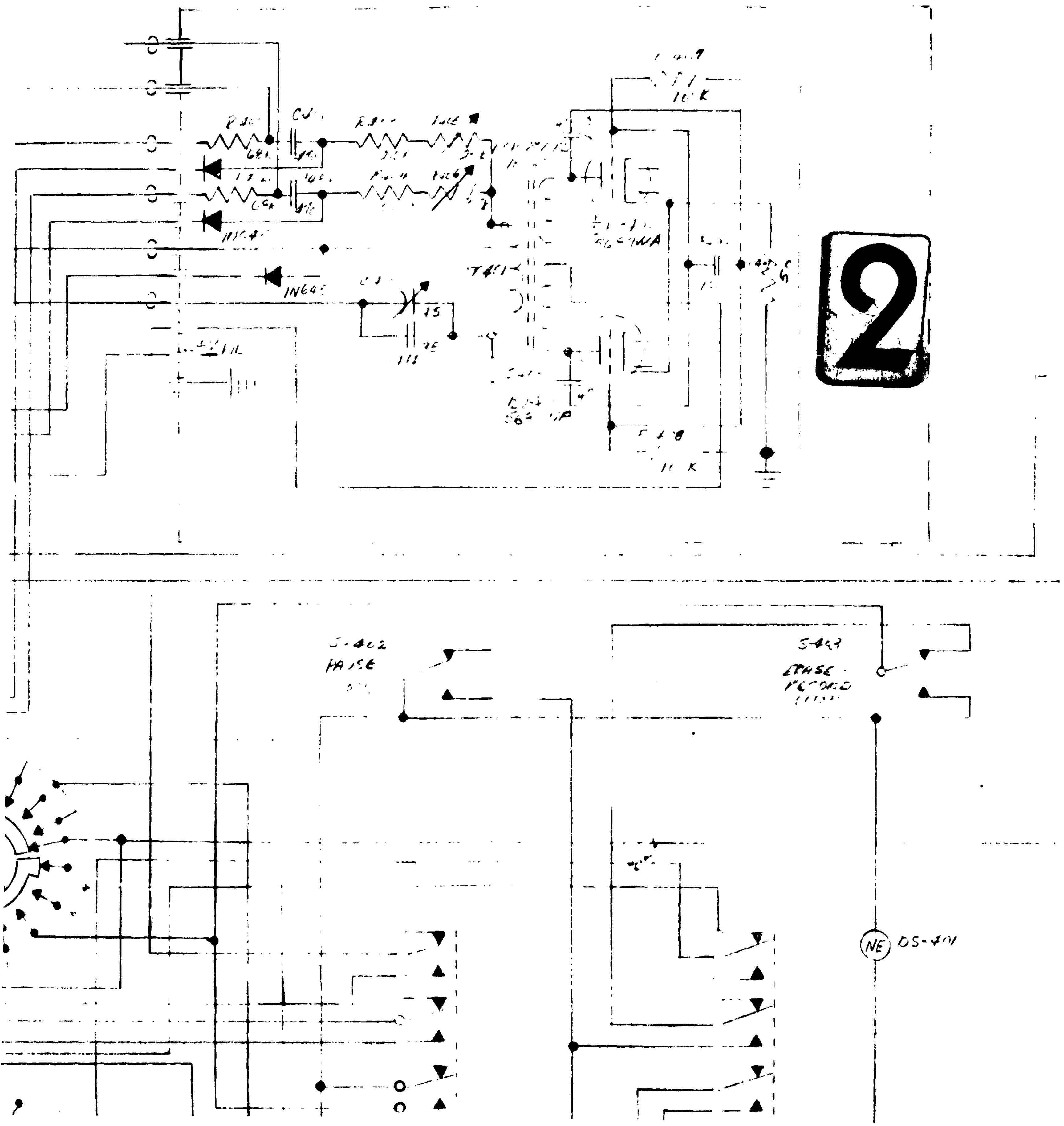

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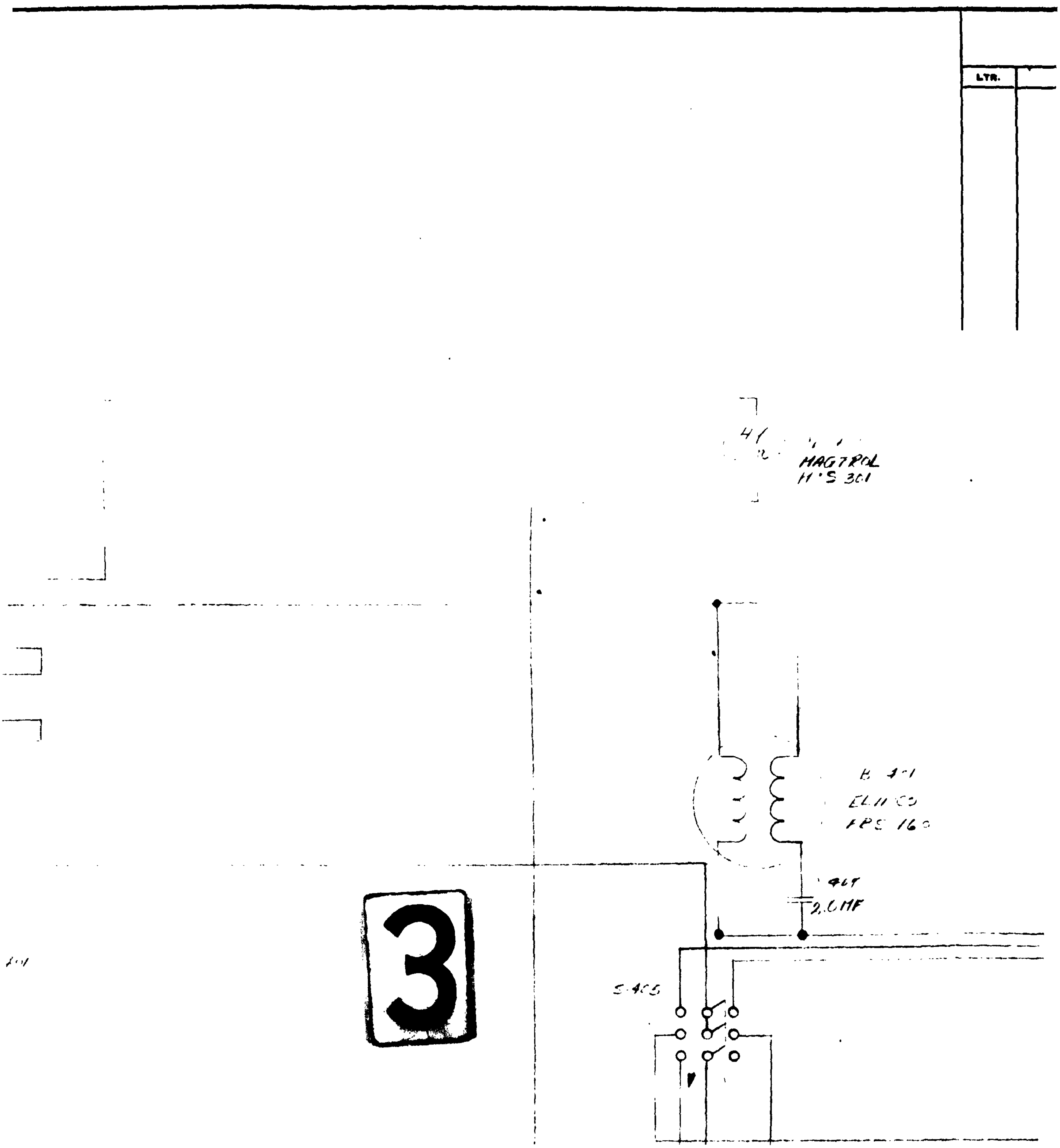
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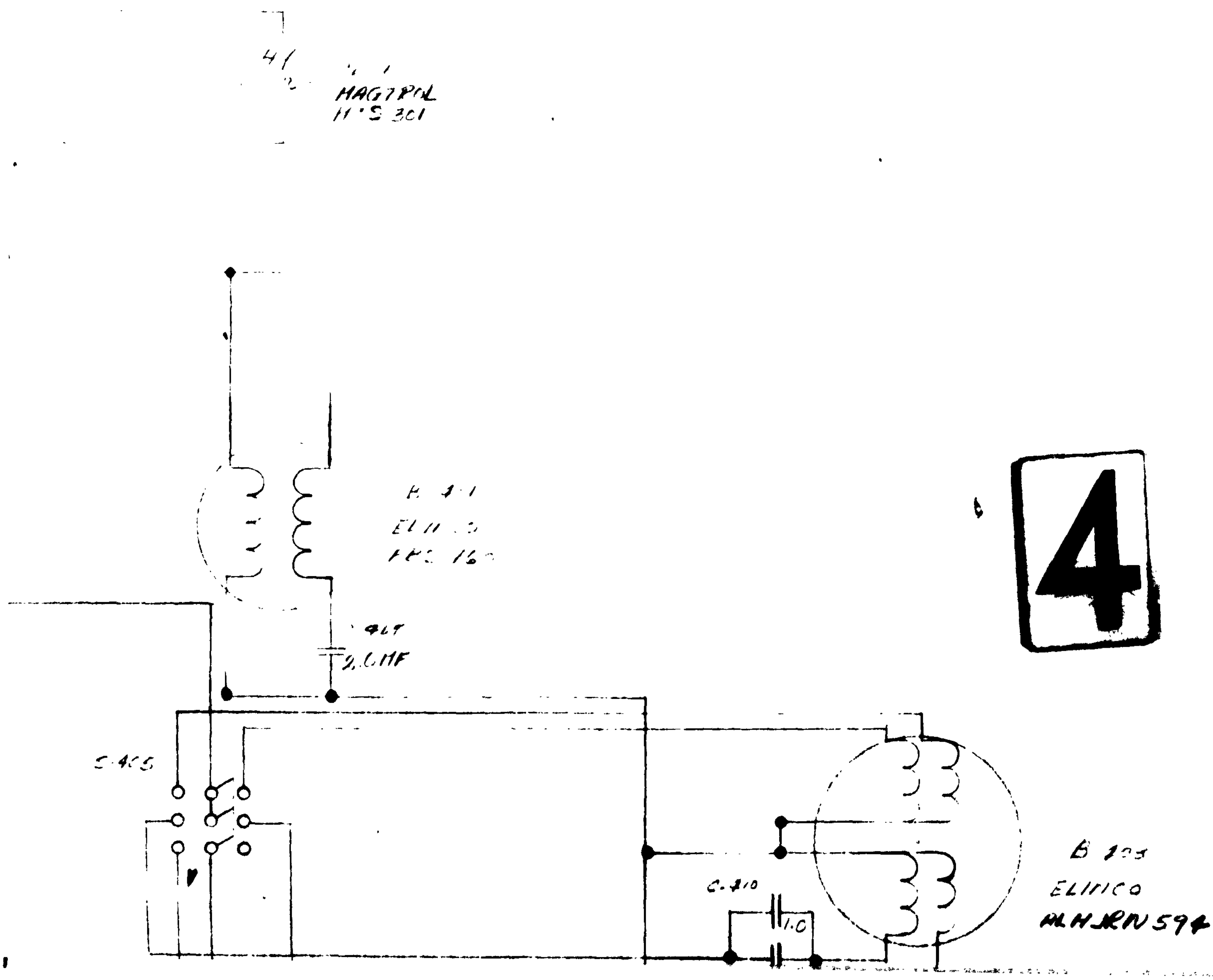

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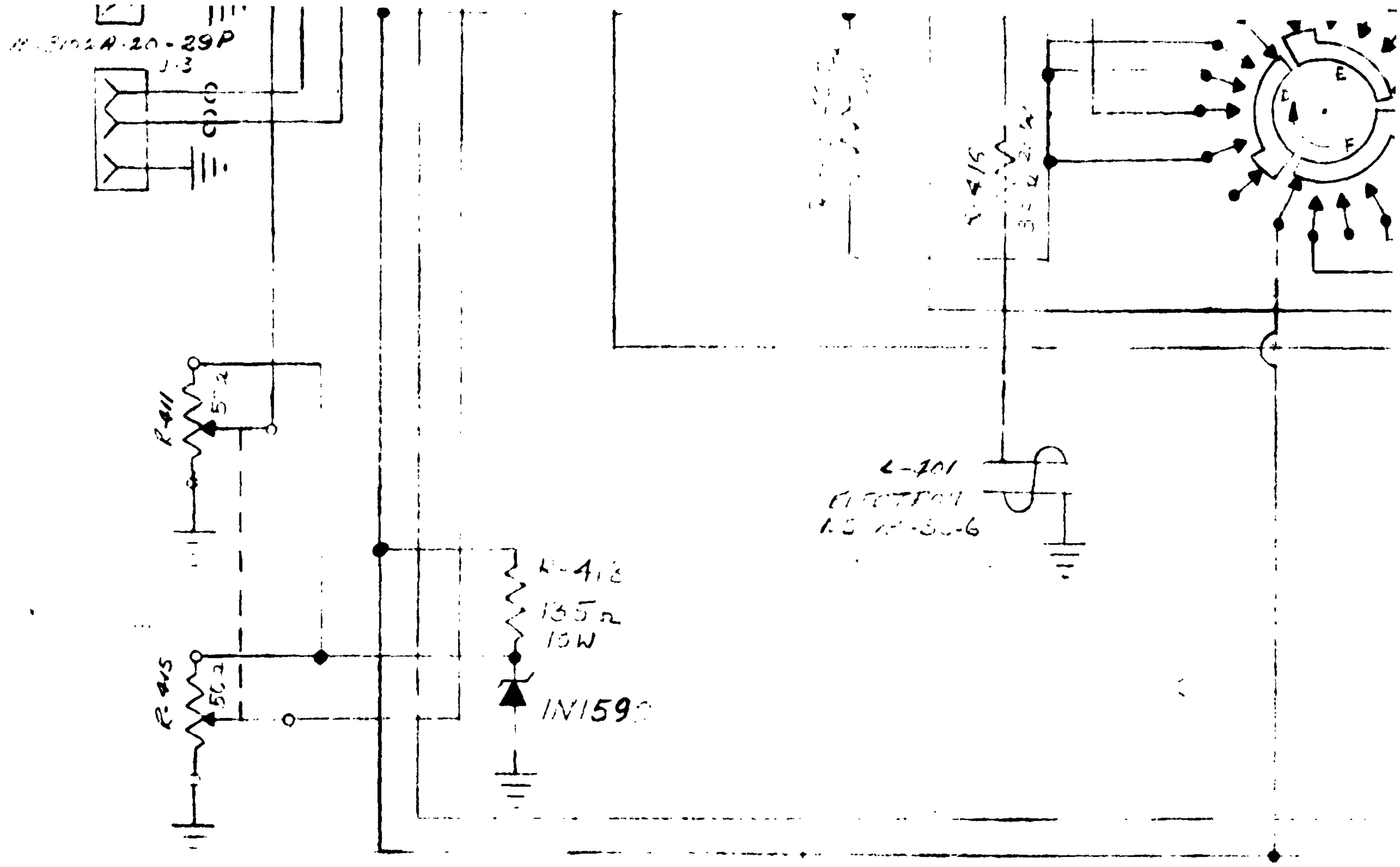

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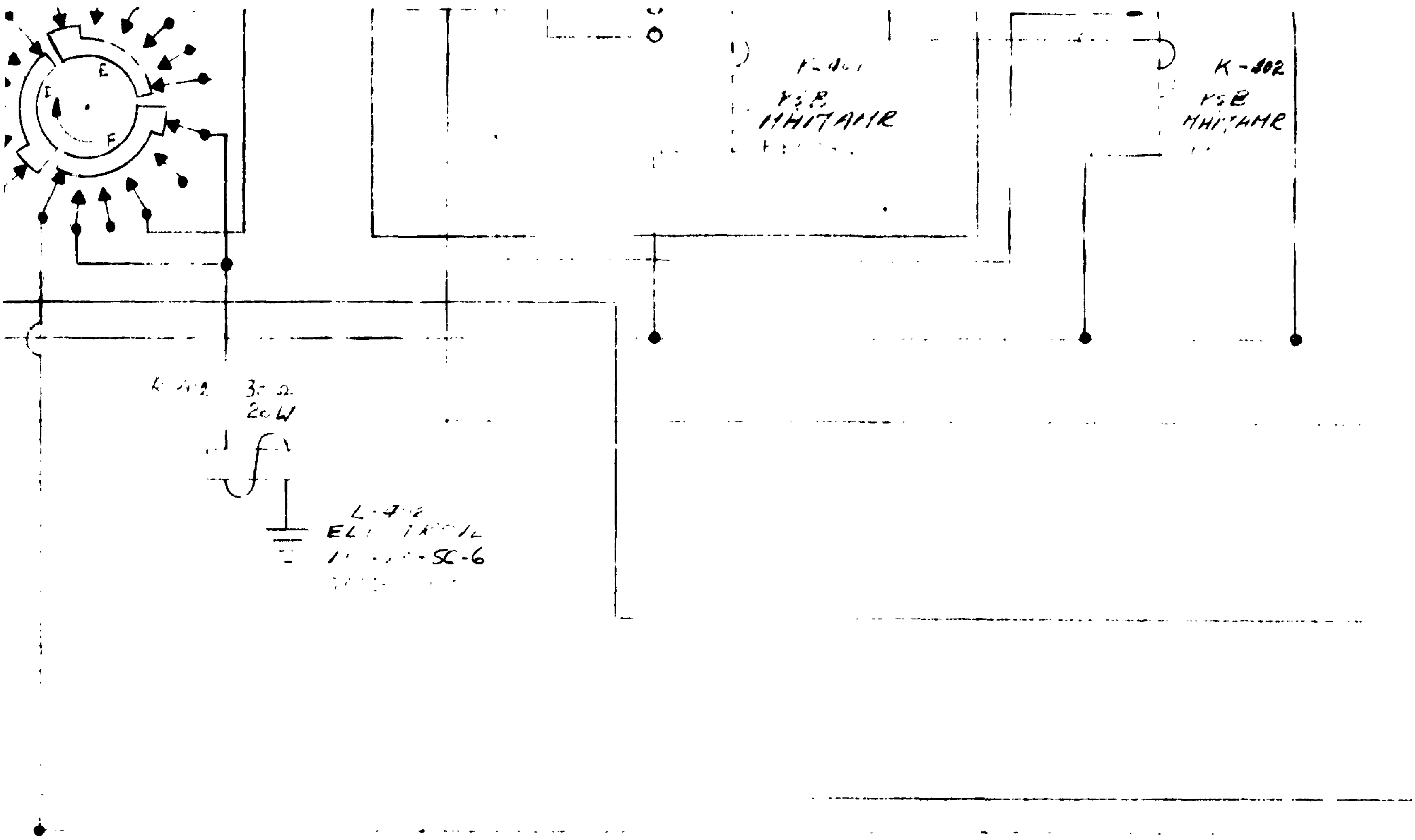

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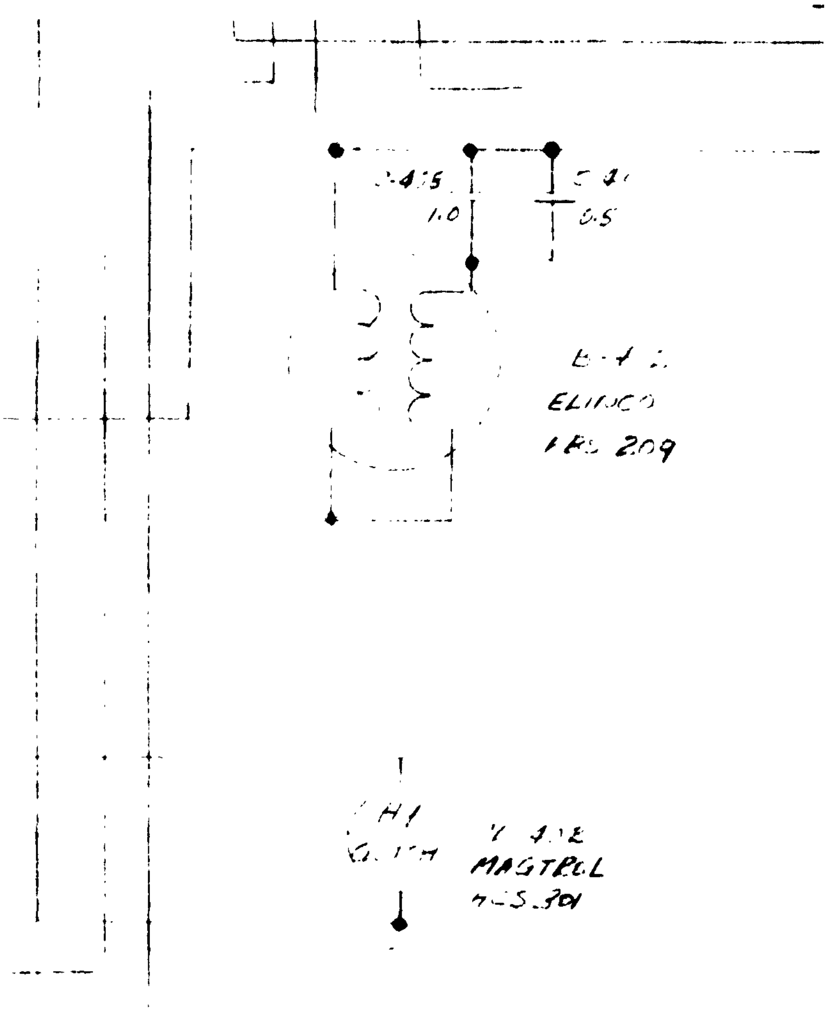

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FINISH:

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APPD.		

VARIAB

RECORD

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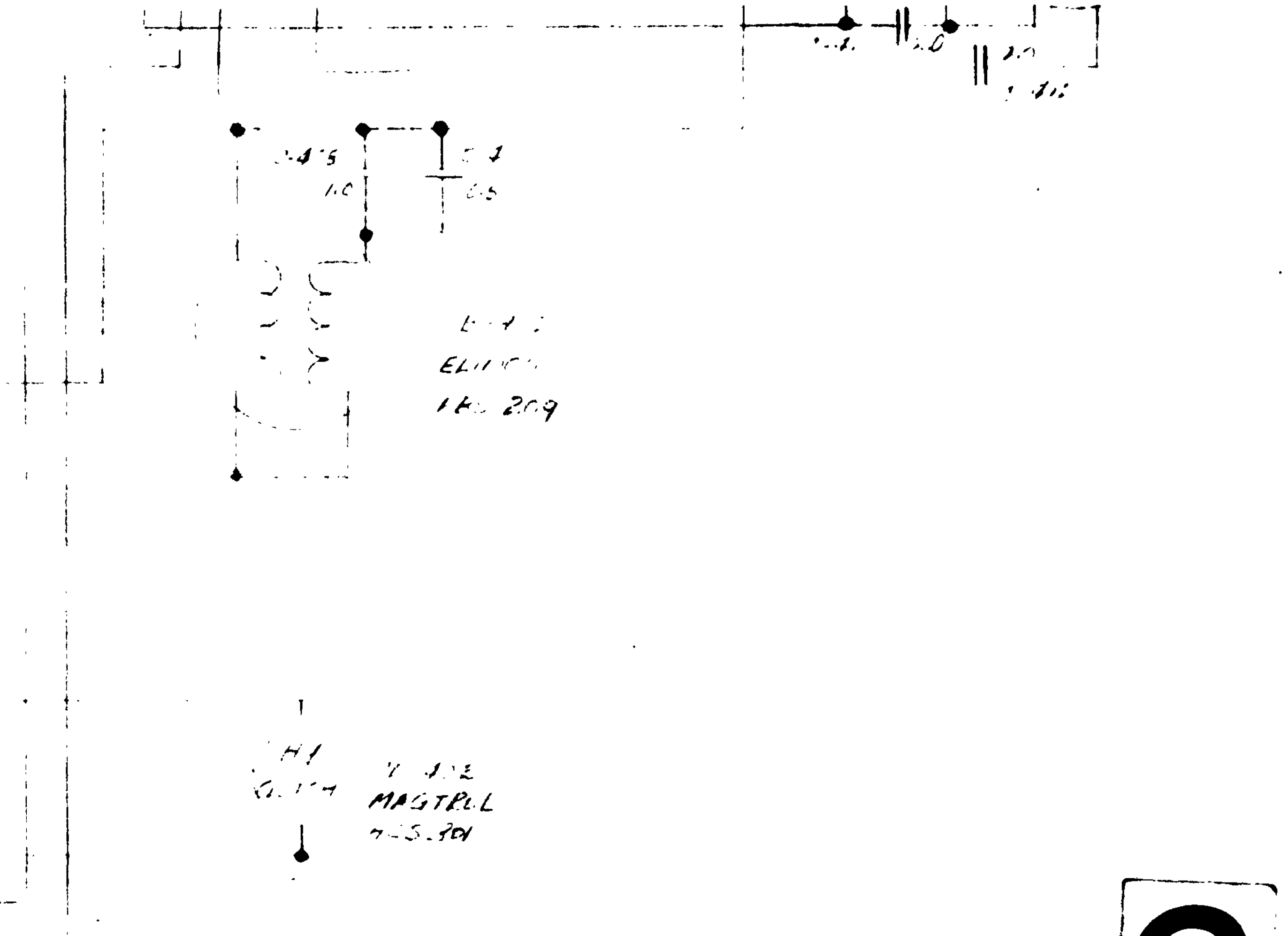

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CHK.	
ENGR. [signature]	1-30-65
APPD.	

VARIABLE SPEED
RECORD REPRODUCER
DIAGRAM

AMERICAN SCIENTIFIC
ALEXANDRIA
VIRGINIA

REV.

SCALE—

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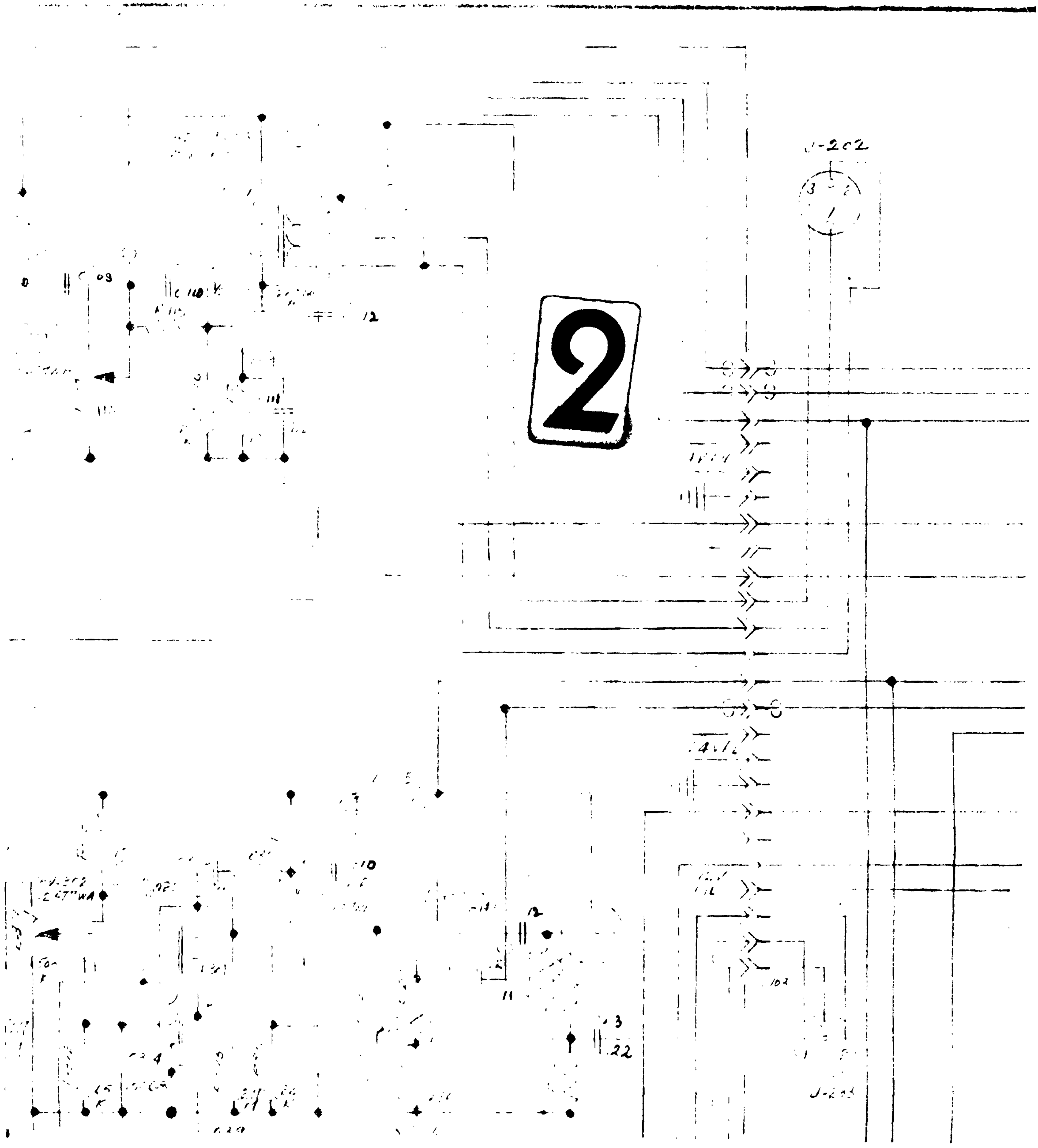
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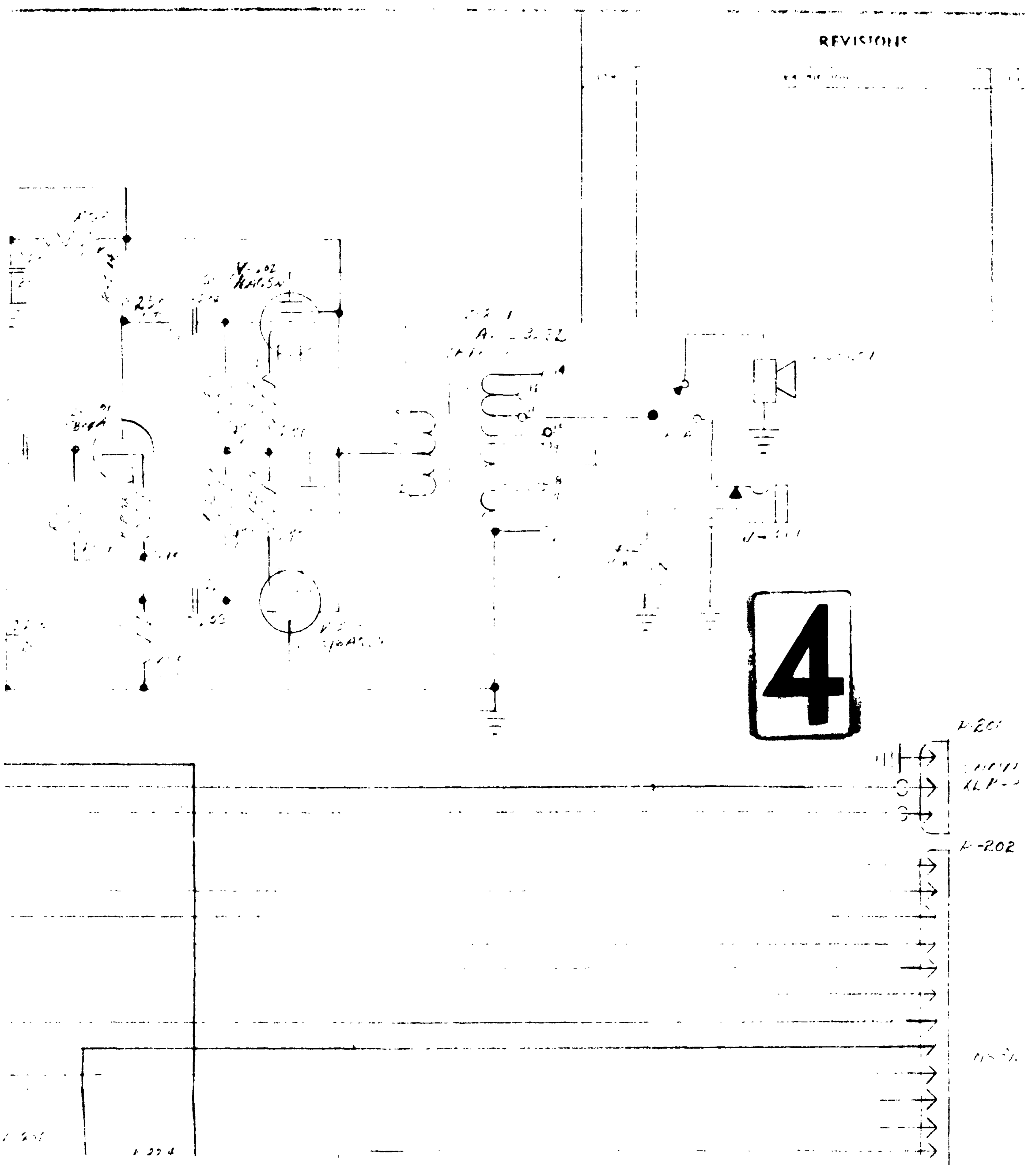
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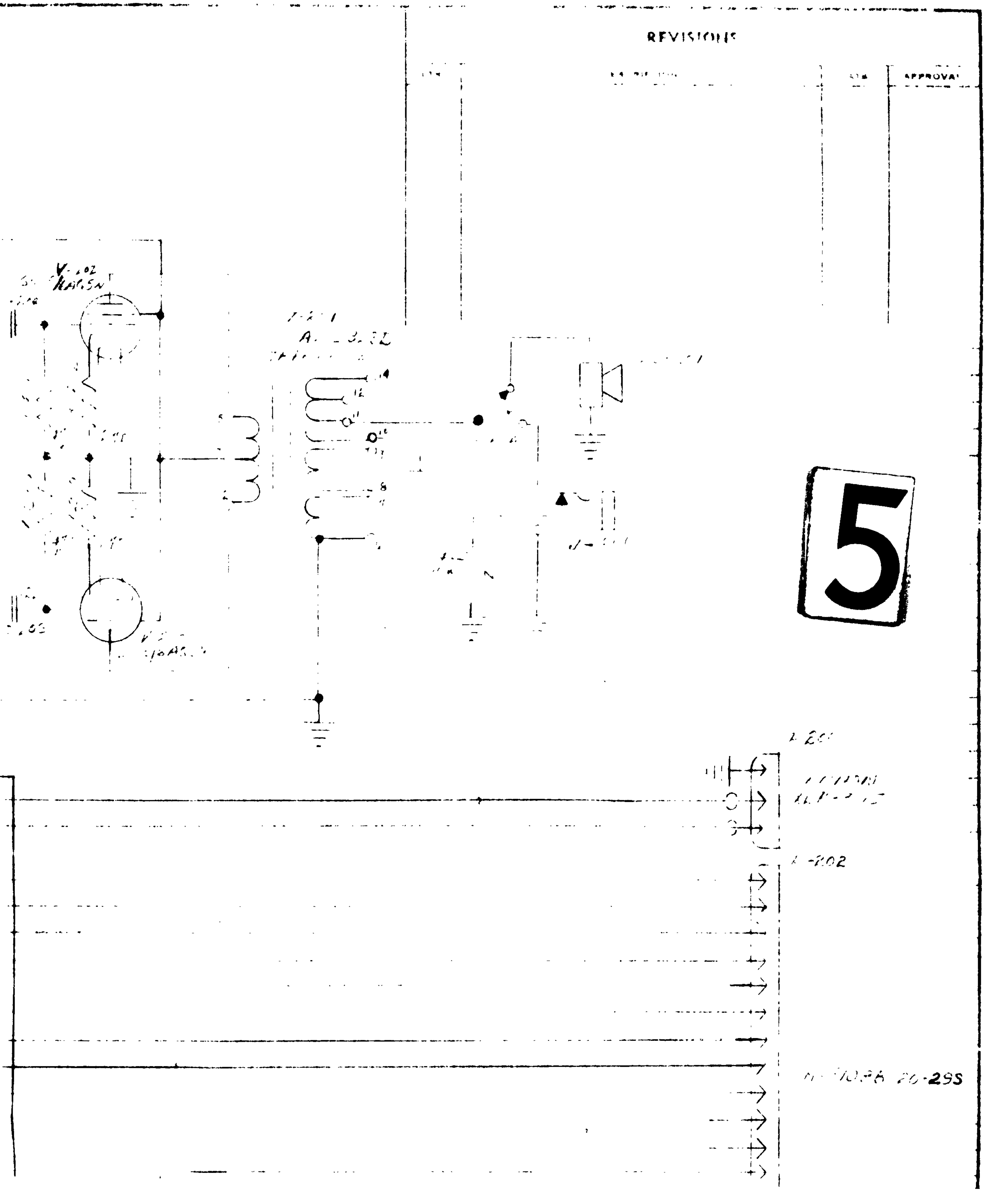
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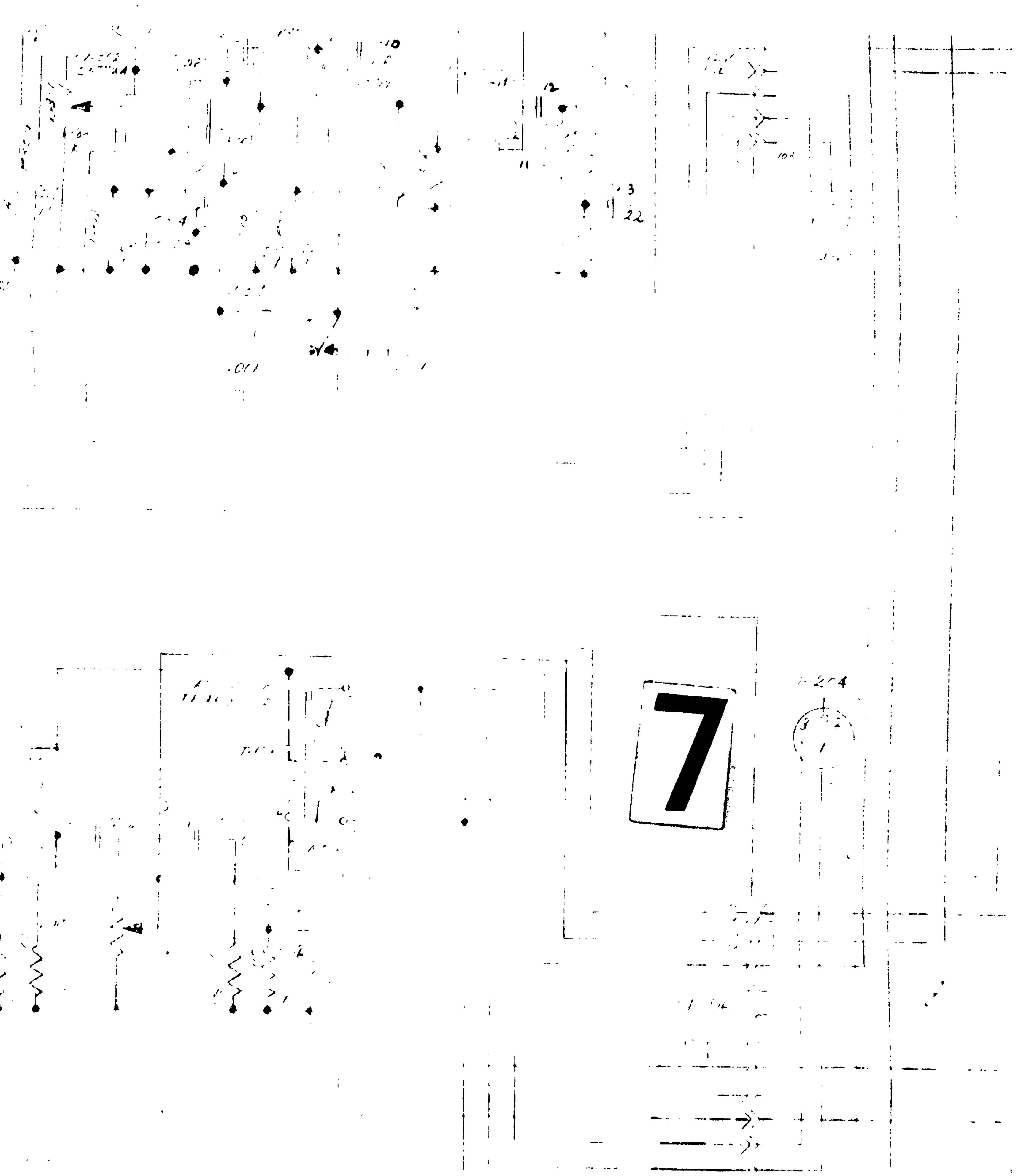
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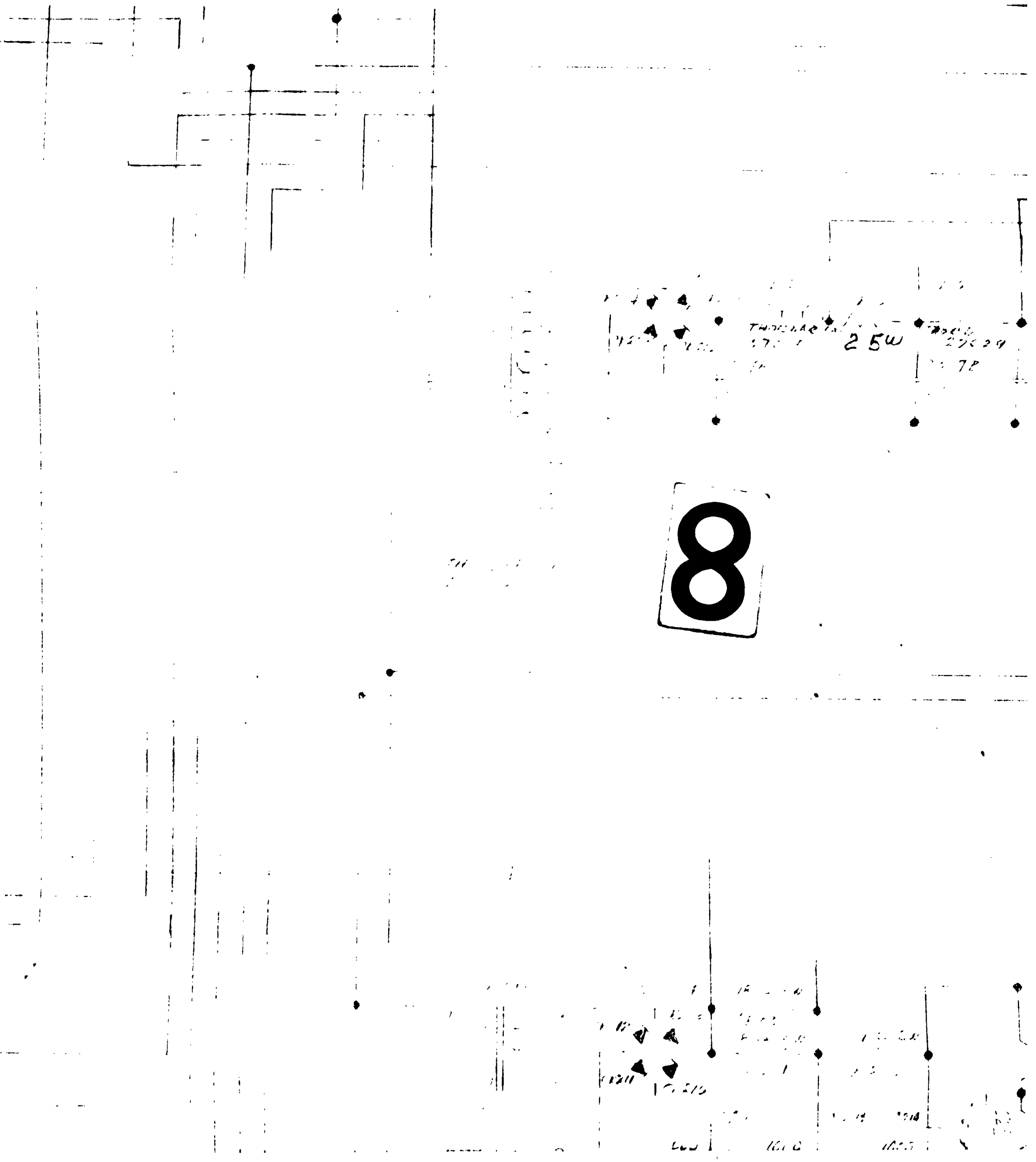
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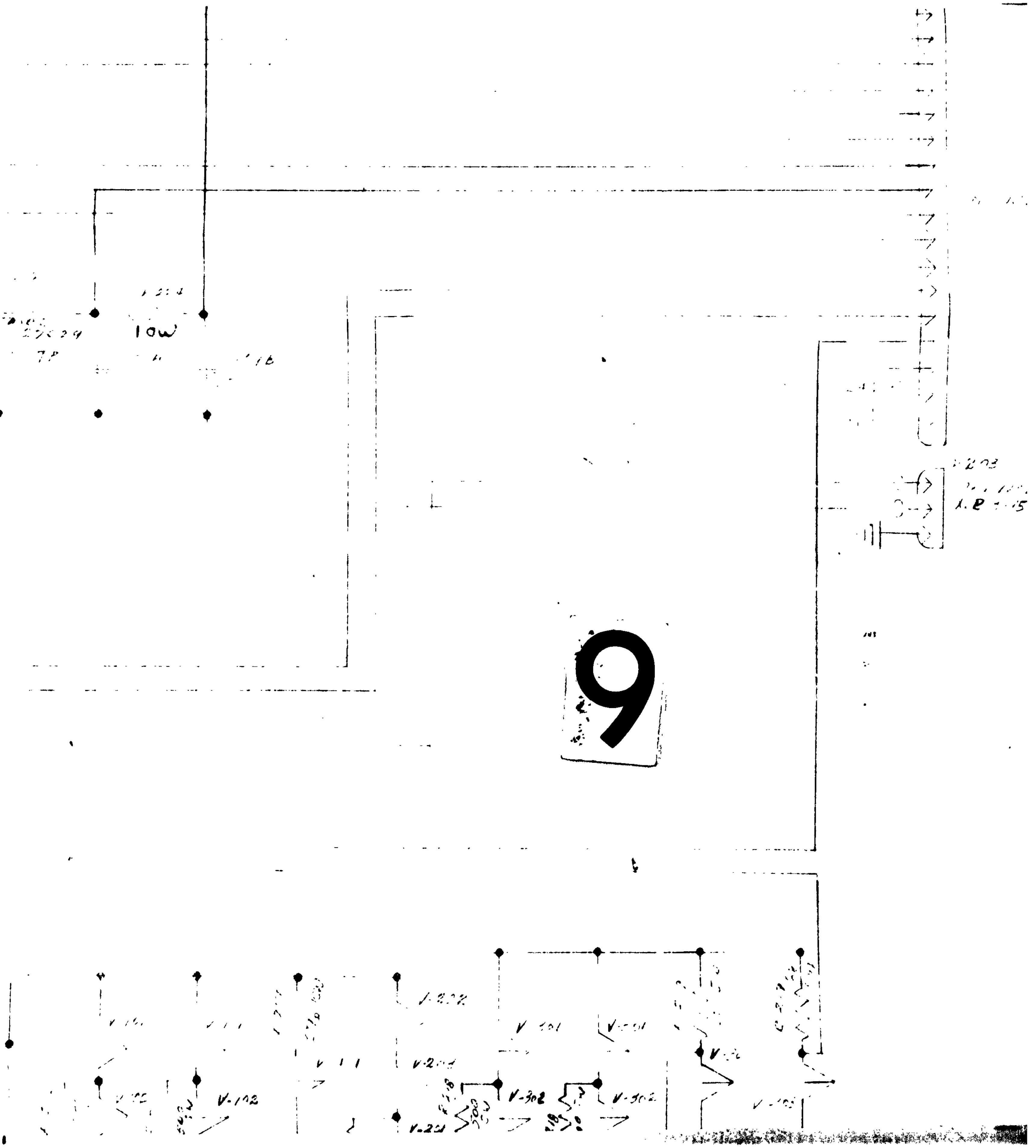
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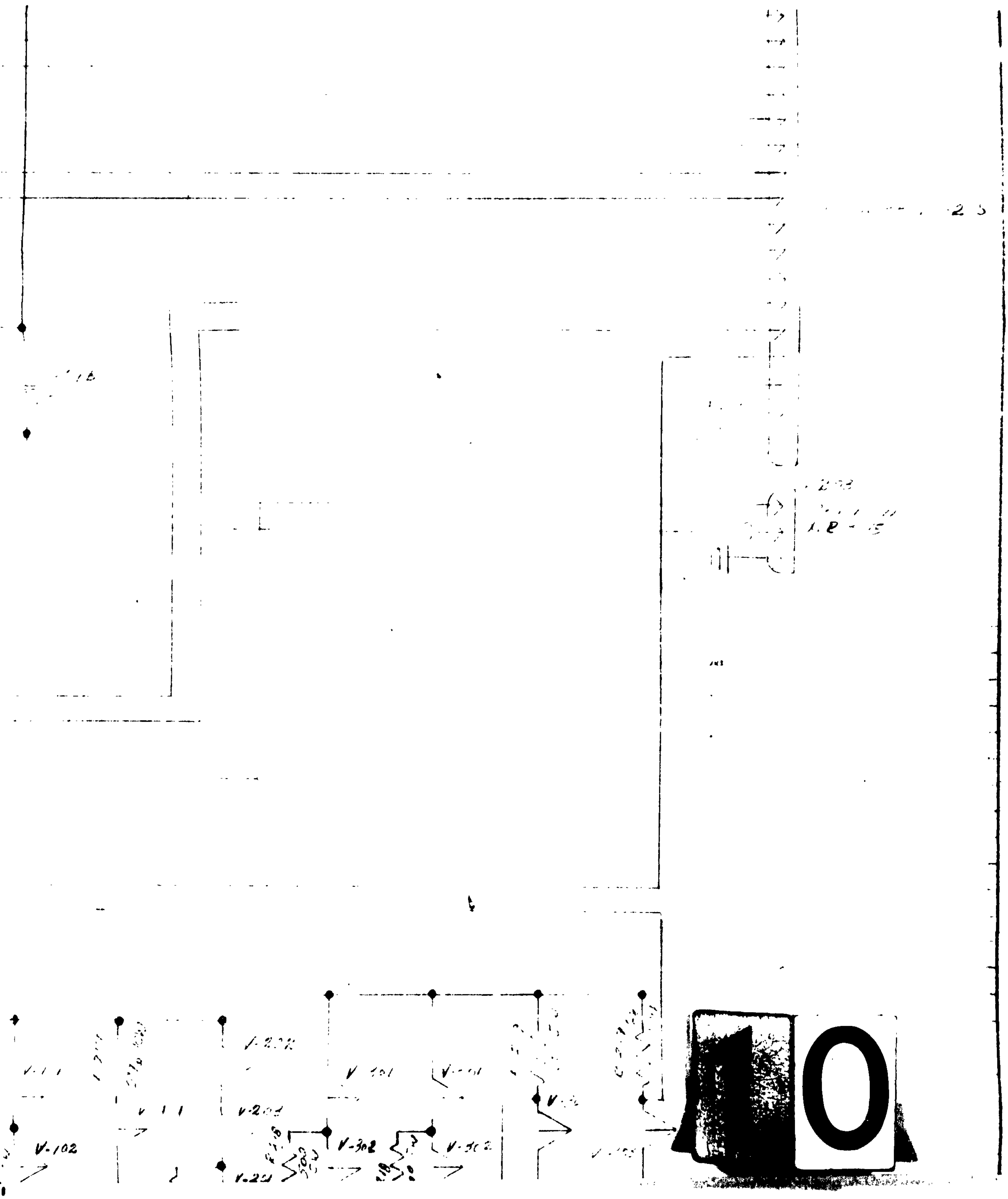
V-302
V-301
V-202
V-201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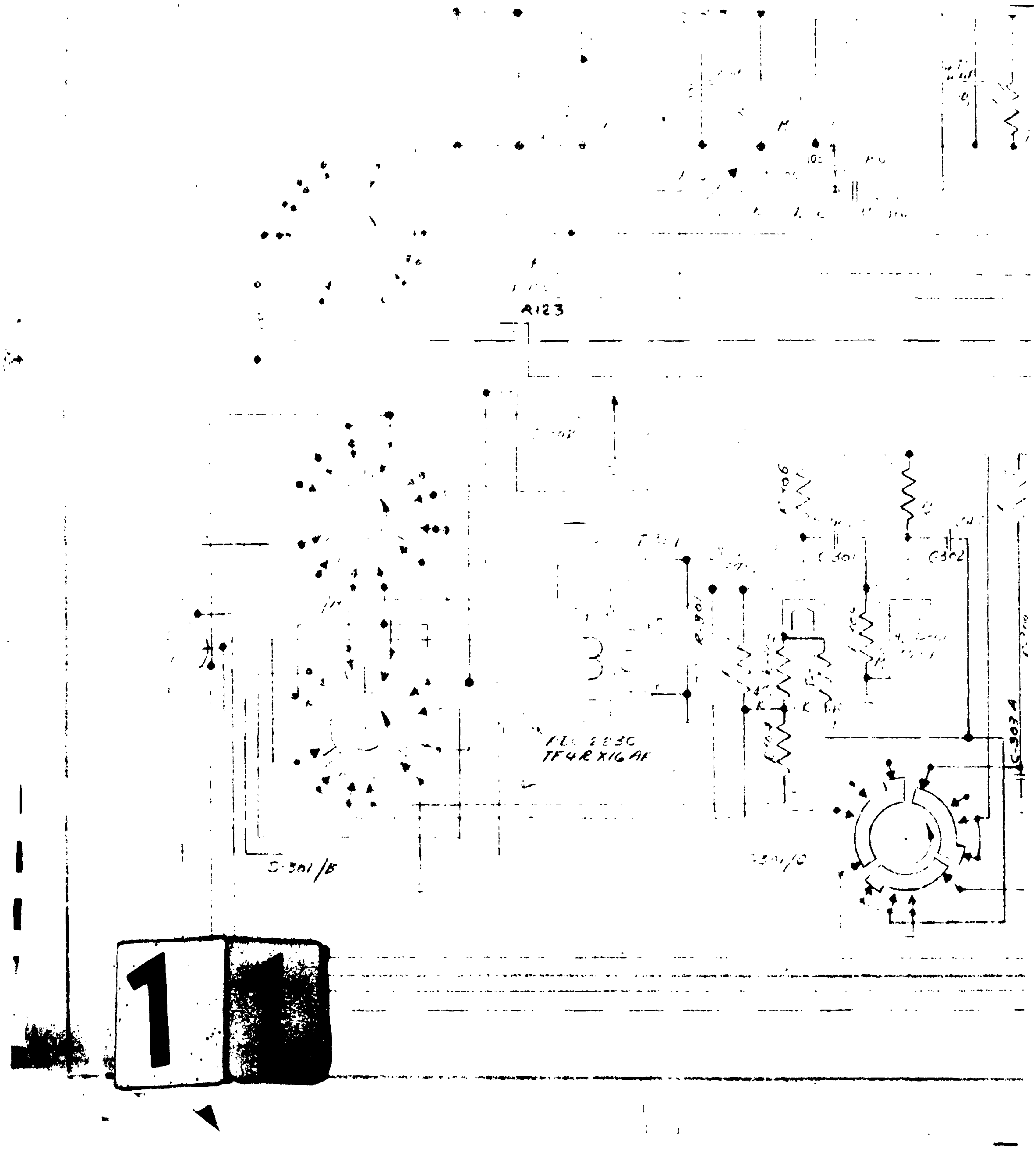
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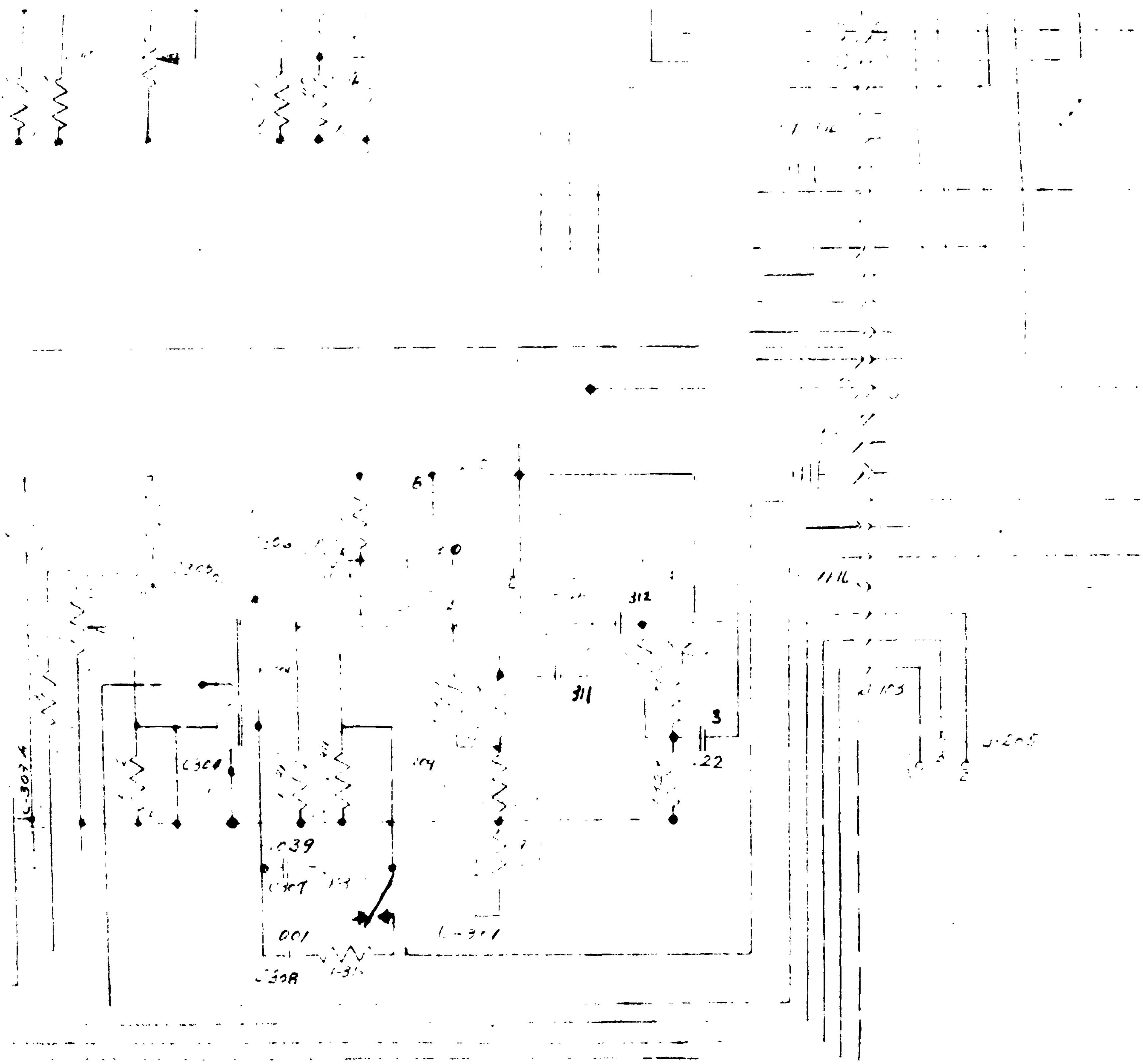

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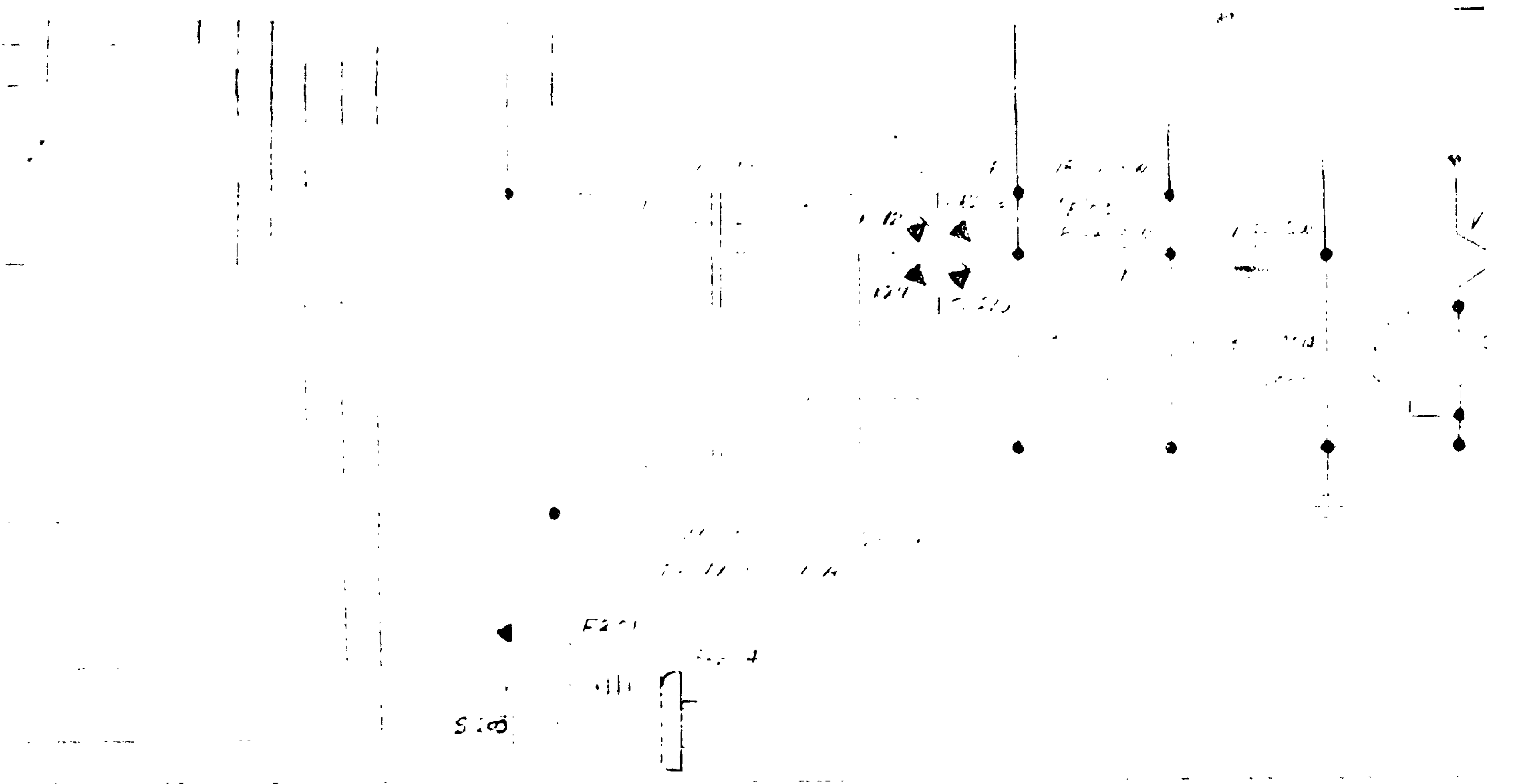

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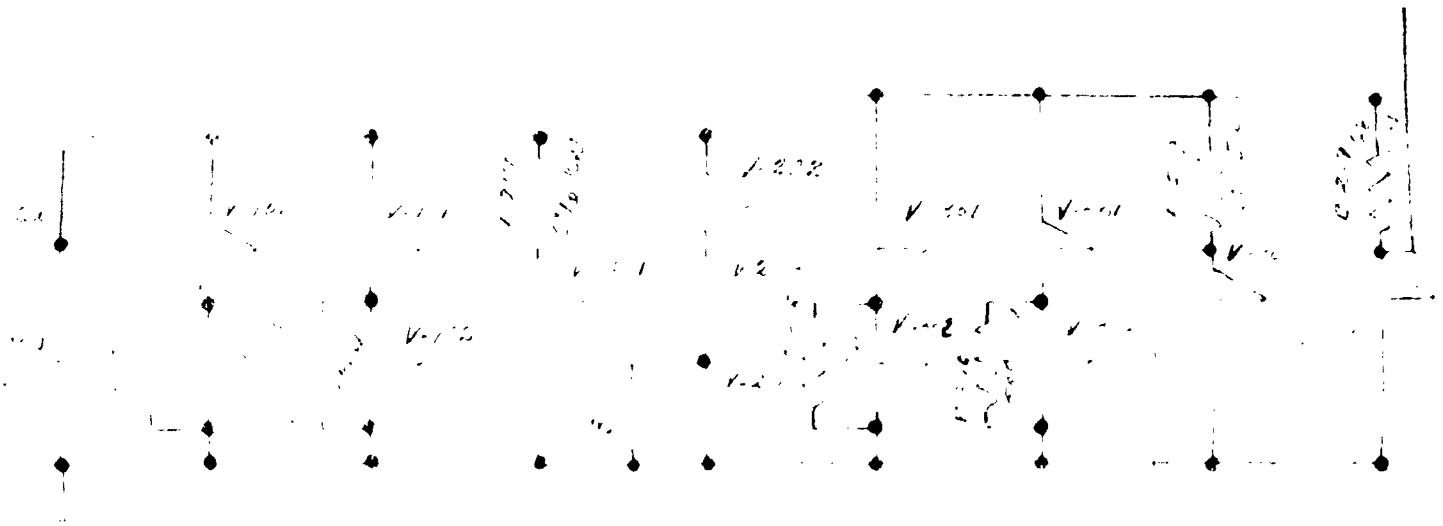

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REQ'D	PART NO	ITEM	DESCRIPTION	MAT'L OR MFR		SPEC OR CAT NO	CKT

LIST OF MATERIAL

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VARIABLE SPEED RECORD REPRODUCER DIAGRAM

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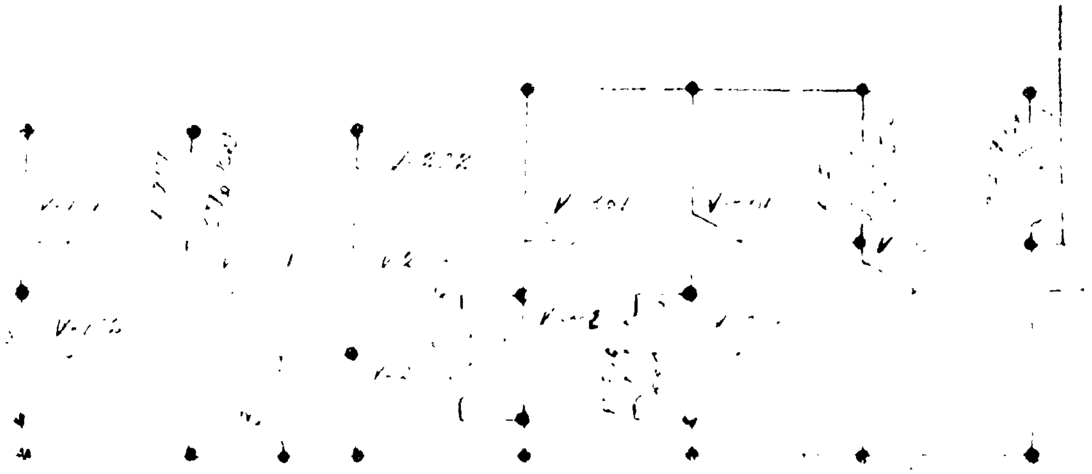

15

REQ'D	PART NO.	ITEM	DESCRIPTION	MAT'L OR MFR	SPEC	DRAWING NO.	REF. SYM.	UNIT WT.	ZONE

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON ANG. ± RMS FIN √	SIGNATURE	DATE		
	DR [illegible]	1-23-63	MULTIPLE FEED RECORD REPRODUCER [illegible]	AMERICAN [illegible] ALEXANDRIA VIRGINIA
	CHK.			
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